IMPACT OF PETROLEUM ACTIVITIES ON ARCTIC ECOLOGY

by

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Panel A, paper #3

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- R.A. Hemstock -

The promise of petroleum development gives hope for great changes in the arctic. It is the responsibility of each of us connected with that development to see that the changes are for the betterment of mankind generally, and particularly for those who are indigenous to the North. In this paper an attempt will be made to evaluate the effect of petroleum development -- exploration, production, and transportation -- on arctic ecology. Ecology is defined as that branch of biology dealing with mutual relations among organisms and between them and their environment.

A polar projection (Fig. 1) shows the current areas of petroleum interest being the Canadian Arctic Islands and Western Arctic, the north slope of Alaska, and the northern part of Western Siberia. The arctic has no rigid definition; it has been correlated with permafrost, the tree line, an isotherm, or some other environmental marker. The following discussion deals primarily with those areas in Canada north of the arctic circle, making use by extrapolation of some of the oil industry experience in the sub arctic.

It is important to first try to assess the potential extent of petroleum resources in the arctic. J.C. Underhill, at the Arctic Symposium in Montreal in March of this year, estimated the potential reserves of the Canadian arctic at 50 - 100 billion barrels of oil and 300 - 500 trillion cubic feet of gas. Most of the potential acreage is now held in reservation or lease and, according to the latest figures, this amounts to about 628,000 square miles. About three-quarters of this, or 470,000 square miles, is on land and the rest lies offshore in arctic waters. The proportions of land and water acreage are reversed in Alaska where the prospective acreage lies predominantly offshore.

These are large volumes of hydrocarbons, yet on the vast areas of land, oil and gas will be found on a relatively small percentage of the total area. Those of you familiar with the close spacing and low productivity of many of the older fields in the world will realize that arctic economics will simply not allow this kind of development. It is reasonable to expect that this volume of petroleum reserves could be produced by drilling about 6,000 - 12,000 development wells.

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It may be helpful to briefly review the exploration and development processes that will lead to unlocking the petroleum potential in the arctic. In general, the oil industry progresses, over a period of time, from operations which have little effect to those which have more and more effect on the ecology. ?

Geological reconnaissance is usually the first exploratory venture. It will be very effective in the Arctic Islands where there is little surficial cover and bedrock is widely exposed. On the Canadian and Alaska arctic mainland it will be restricted to outcrop areas. Most of the work will be done by helicopter or light aircraft and there will be no appreciable effect on arctic ecology.

Geophysical reconnaissance and detail follows. This involves moving men and equipment first on widely spaced lines and later at closer intervals to detail the most prospective areas. This work may be done by helicopter although this has proven to be very expensive. Tests are also under way this summer using air cushion vehicles. It is more common, however, to use either trucks, tractors and sleighs or low ground pressure tracked vehicles in winter, with the tracked vehicles being most economic and now in general use. Some of the geophysical work in the past has been done without due regard to the environment and has resulted in disturbance or destruction of the organic cover resulting in subsidence in those areas where soil ice content is high. It is now the practice to work in winter on the snow cover with low ground pressure tracked vehicles and, where reasonable care is used, there is a minimum of surface damage and no thermal erosion follows. Summer operations expose tundra to track scuffing and cutting and, unless great care is used, there is generally some damage to the surface although usually not enough to cause serious damage. Since economics favour year-round operation, industry is interested in improving the capability to work in summer. Economic favour There are two obvious approaches. One is to develop vehicles which do not damage the surface. This may be by modification of present tracked vehicles with a less aggressive track, or possibly by conversion to aircraft or air supported vehicles. A second possibility is the use of some type of cover which will prevent the scuffed surface from melting and, at the same time, encourage natural

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growth and stabilization.

Damage to tundra terrain is not the only concern in conducting summer operations in some parts of the arctic. For instance, a good portion of the Mackenzie Delta area is a prime breeding ground for migratory waterfowl and must be protected from large scale human intrusion during the nesting period.

Geophysical exploration is followed by exploratory or "wildcat" drilling. Unfortunately the odds do not favour discovery of oil at every wildcat or even at one out of every ten wildcats. Thus exploratory drilling is generally a "one shot" effort and transportation costs must be minimized as must the cost of site preparation. Rigs and heavy equipment are founded on piles or on thick fills with supplies and working space on thinner fill. Unless there is trouble in drilling, a site of 3 - 4 acres is usually sufficient. Most exploratory drilling has been done in winter because of easier transportation and better site conditions. Many of the earlier winter roads were prepared by bulldozing off snow and much of the moss and travelling on the permafrost surface. The following subsidence and erosion has left obvious scars on the arctic. It has been found quite practical, however, to travel on a snow and ice road built on the undisturbed surface. Costs are quite reasonable and there is little or no damage to the tundra. Since the arctic is an arid region, the snow cover may be light and late arriving, which can delay start of winter operations.

$ cost only

Development installations are more permanent and roads to each location can usually be justified. In very difficult terrain the general practice is to drill one vertical and several slant holes from a single location. This approach will likely be taken in many areas of the arctic since there is a large saving in surface facilities. It is understood that present plans call for the development of Prudhoe Bay in this manner. Provided suitable fill materials are available, there will be no difficulty in building stable roads and wellsites. The most readily available fill material will be found in thawed river or lake beds. Large quantities of material removed from these sources could disturb the existing ecological system and this should be a matter of careful study as work progresses.

On what basis?

yes

Production facilities in the arctic will be highly automated and, in fact, computer production control will likely pay off. Every effort will be made to minimize the surface facilities, in particular oil storage. The wells will be connected as directly and simply as possible to the pipe line or shipping terminal. One of the problems will be how to handle the hot oil from the wells. Such pipe lines cannot be ditched into the permafrost because of the resulting instability due to thawing, and it is likely that most flowlines will be insulated and laid on the surface or carried by piles.

Terminal storage, although minimized, will still require some large tankage. Where this is founded by necessity on icy permafrost, very well designed foundations will be required since the oil produced at high rates will bring with it great quantities of heat. Such tanks must be essentially isolated from the permafrost. Since there is some freedom in location of terminals, it may be possible to locate most oil storage on gravel or bedrock that will not be affected by thawing.

Main trunk pipe lines will also be carrying quantities of heat in the oil and will have to be isolated from icy permafrost. They may be safely buried in low ice content gravels or sands or bedrock. The Russian practice is to lay lines on piles or supports across permafrost and, although this practice has so far been restricted to gas lines, it is likely that it will be required for hot oil lines.

The construction of major trunk lines in the arctic will require the most resourceful engineering approaches. Only the larger lines will be economic and this will require the heaviest pipe handling equipment available today, plus the hauling of hundreds of tons of pipe and equipment along the right-of-way. It may be possible to protect the tundra with granular fill and by working only in the appropriate seasons; however, the logistics problems and work scheduling will be a challenge to arctic planners. It is recognized by pipeliners that only a stable environment will support a large pipe line, and studies are proceeding to this end.

These are, then, the phases of oil development in the arctic. Support will be provided by roads, airfields, camps and towns. Perhaps one of the most disturbing factors will be the

increase of population, either permanent or transient, in remote areas in order to accomplish the scale of development contemplated. This will put pressure on recreational areas and such renewable resources as fishing and hunting. At the same time, however, there will be provided a challenge and an opportunity for improvement to the arctic's most valuable resource -- the people. ?

In summary, the 470,000 square miles of potential oil lands in the Canadian arctic will require for development:

(a) Extensive geological reconnaissance.

(b) Reconnaissance and detailed geophysical surveys for a total of 150,000 miles.

(c) Drilling of 700 - 1,400 exploratory and 6,000 - 12,000 development wells for petroleum.

(d) Construction of 4,000 miles of access road and 4,000 miles of trunk road based on Northern Canada experience of one mile of road per well.

(e) Construction of 8,000 miles of gathering pipe lines and many miles of large trunk lines to market or to marine terminals.

(f) Construction of camps, towns, airfields, and support facilities for an additional population of 10,000 oil workers.

To provide for this effort in arctic Canada the total area directly involved in petroleum development will be 13,500 square miles or approximately 3% of the potential oil lands. Similar percentages may be expected in other parts of the arctic. Thus the effect on the total environment should be small; however in development areas there will be an impact and the long term effects must be well understood. agreed.

It is generally believed that the ecology of the arctic is in a very delicate balance and that the life of plants and animals is in a precarious position when even slight changes

occur. This is of particular concern to the petroleum industry since even slight changes in the environment might trigger a chain reaction. The best safeguards will be provided by basic studies of the ecology including careful documentation of past experience.

One Canadian example can be cited -- the development of the Norman Wells pool in 1943-45. This was a wartime venture and wells were drilled, pipe lines and roads built, and large areas stripped for storage without any great regard for the effect on the environment. For the first few years there was an excess of water as the permafrost receded. However, there was very little erosion due to the thick organic cover and a new set of stable conditions soon emerged. Permafrost in this area recedes seasonally to a depth of 18" in undisturbed areas and to 8 to 10' depth in disturbed areas. Frozen soils in the top 20' average about 40% ice. There is now little evidence in the field of environmental change, flowline rights-of-way, wellsites and seismic lines have grown back with secondary cover.

Such a rapid return to stable conditions will likely occur in most of the taiga areas; it may not occur so rapidly in tundra areas where there is less vegetation and higher ice content in the soil. Unfortunately there is little precedent here although a review of the DEW line sites might yield helpful information.

Research on these problems is under way at many centres using many different approaches. Probably the most basic of the work is aimed at understanding the heat balance associated with man-made structures on or in permafrost and in finding methods to prevent the deterioration of permafrost. In the high arctic the passive method of construction will likely be favoured -- that is, the maintenance of permafrost and its use as a foundation material. Isolation of structures from permafrost by piles is old and is well known. It has been used, for example, in the founding of large Russian cities on permafrost. No new problems are anticipated by the petroleum industry except perhaps in the sheer size of some of the structures needed.

Roads, airfields, and other fill structures on permafrost

do not present any new problems. The important factor is simply the retention of permafrost in its original frozen state. The heat balance problems are fairly well understood and there should be little effect on arctic environment.

Work directly on the tundra is not so well known or understood. The disastrous results caused by stripping moss cover by men and equipment or perhaps by fire (Fig. 2) are now being documented. It is perhaps worth noting that in the decade 1956-65 an estimated 389,000 acres were destroyed by fire annually in Northern Canada. About 60% of the damage was caused by naturally ignited fires over all of Canada, and about 80% in the northern areas. Damage by men and equipment occurs chiefly where the underlying material is icy permafrost. Research is presently going on in Canada to determine if it is possible to classify the ice content of soils by aerial photograph interpretation. This is an extension of the work that has been successful in muskeg interpretation. There are other useful approaches which are being examined. These include:

(a) Design of vehicles which can travel over tundra without damaging it; e.g., air cushion vehicles, soft large tires, flat smooth tracks.

(b) Isolate the vehicle from the ground by mats of plastic or steel. This has been tried but so far is quite costly.

(c) Develop methods which promote rapid recovery of the damaged surface. Test plots were set out in 1968 at Inuvik and Tuktoyaktuk featuring reflective materials, insulation and fast growing grasses. Results are encouraging.

The production of oil contributes little to air or earth contamination; products are piped, separated, and stored in closed vessels and arrive at markets with a minimum of handling. While it has been pointed out that relatively small areas will be directly used by the petroleum industry, it must be recognized that any change is a further contribution to man's attack on his environment and part of the trend of bending the environment to man's use. However, the finding of petroleum will lead to lower cost energy, making it easier for man to

<u>live in the arctic and possibly enable him to improve the renewable resources of the area.</u>

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In North America the petroleum industry has, by its own initiative, and by government regulation, set a high level of standards for field operations. These standards will be maintained in the arctic and know-how will be developed to safely operate in this new and severe environment.

In conclusion, one cannot but agree with Dr. McTaggart Cowan when he says, "In the northern lands knowledge of the appropriate ecological facts is indispensable if we are quickly to recognize the alternative opportunities for resource development and the constraints within which we must conduct our activities. Here, even more than farther south, man will continue to live in the closest contact with the natural environment. His success will depend as much upon the sophistication of his ecological knowledge as upon his technical competence to respond."

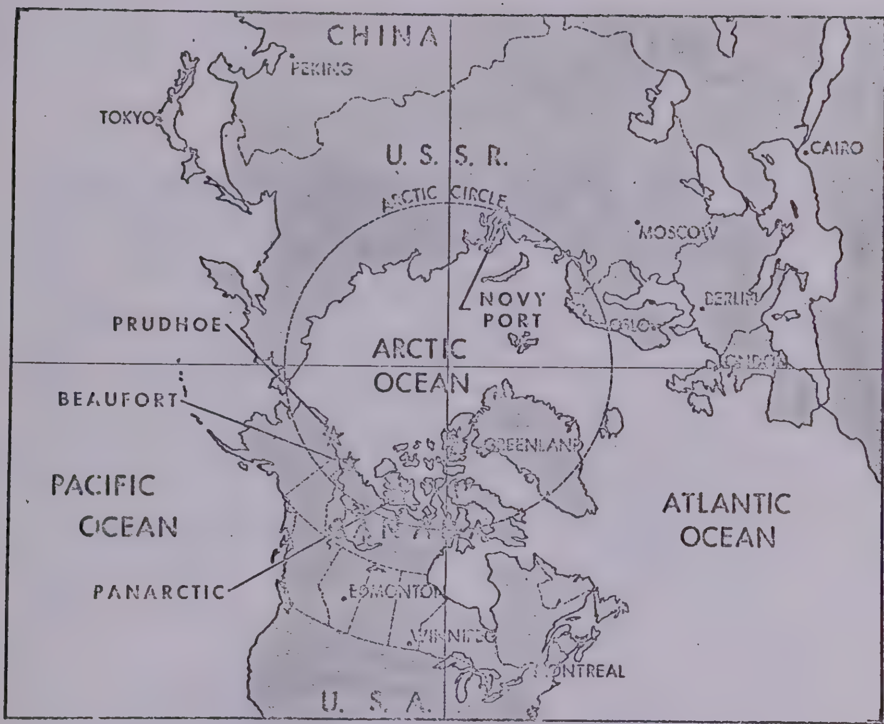

FIGURE 1

Polar Projection Showing Active Exploration Areas

FIGURE 2

Ice Mounds Denuded by Forest Fire near Inuvik

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